Problem Statement:

There exist many underserved Communities around the world that do not have access to Reliable Electricity/Money to operate Climate Control Devices like Refrigeration, Air Conditioning, Heaters etc. Regular solutions are usually Expensive, Power-Hungry and Bulky/Non-Portable
This problem mainly affects people living in Low-Income areas like Slums, Villages etc

This problem is important because it affects the Health, Comfort, and Daily Lives of people.
Lack of Temperature Control systems can lead to spoiled Food or Life-Saving Medicine, Discomfort, or even Serious Health risks during extreme weather (Heat Strokes, etc)

Our team wants to solve this by providing a Low-Cost, Energy-efficient, and Portable solution that can help these communities stay Safe during extreme weather conditions, keep their Perishables (Food, Medicine) Safe and improve their Quality of Life.

Our Proposed Solution:

Our Proposed Solution is ThermaVault -- It is a Solar-Powered ThermoElectric Device that can either Heat or Cool a small Insulated space to specified Temperatures, It can also generate electricity when exposed to hot/cold objects.

ThermaVault works using a 'Peltier module' that creates a hot and a cold side when powered (Uses the Peltier Effect). By switching the Electric Current direction, It can achieve either Heating up or Cooling Down the inside of a Thermally Insulated box. It can also work in reverse using temperature differences to generate small amounts of Electricity (Seebeck Effect).

This device can help people with:
Keeping Food, Medicine, Perishables at Safe Temperatures
Use it even in places with No/Unreliable Electricity
Generate small amounts of Power/Electricity using Temperature Gradients
Stay Warm or Cool in Harsh Climates

Main Components:
Peltier module (for Heating/Cooling)

Heat sink and Fan
Temperature Sensors
Microcontroller
Lithium-ion battery + Solar Panel (Optional)
Thermally Insulated box
Power generation Circuit (uses the Seebeck effect (reverse Peltier))

Steps to Implement/Build it:
1. Build a Thermally Insulated box (to keep the Heat or Cold inside)
2. Install one/multiple Peltier module/s
3. Add a Heat Sink System with a Cooling Fan (for efficient Heat transfer)
4. Install Temperature Sensors inside the box (to monitor the temperature).
5. Program the MicroController (to Manage Temperature)
6. Connect a Lithium Battery + Solar Panel (for off-grid power) (Optional)
7. Add a System for switching between Power Generation or 'Heating/Cooling' modes
8. Test and improve the prototype based on the Test Performance
9. Design a portable and user-friendly enclosure for real-world use.

Potential Impact of the Project:

Our Project has the potential to create a positive impact both socially and environmentally by:

1. Reduces dependency on Fossil Fuel-based Electricity/Power:
Most Traditional Temperature Control Systems use Power that is generated from Coal or Fossil Fuels, Our Project offers a solution by using solar power which can greatly reduce the Carbon Emissions that would be released to produce that Power from Fossil Fuels.
According to the IEA (International Energy Agency), every 1 kilowatt-hour (kWh) of electricity saved from coal power avoids approximately 0.9 kg of CO_2 emissions. That means Even a single ThermaVault saving 100W of cooling daily avoids over 32 kg of CO_2 per year!

2. Replaces Bulky, Power Hungry equipment with a More Portable and Energy Efficient one:

A traditional refrigerator uses around 100–200 watts, while a small Peltier-based cooling device like ThermaVault uses way less, Around 40–60 watts, depending on the conditions, That's about 50% energy savings right there!
Plus Devices like ThermaVault do not require Compressors to operate (which are usually bulky and extremely power hungry)

3. Promotes Renewable Energy Usage in rural areas:
In such Underserved areas where people usually rely on Kerosene or Diesel for heating or lighting, ThermaVault offers a Clean and Smoke-free alternative, This reduces local air pollution, black carbon (soot), and household emissions, Which are all contributors to climate change.

4. Encourages Innovation:
Because our Project uses easily available and low cost Components to make, This design can easily be replicated and scaled up by more people/communities encouraging Innovation and Climate Awareness Activities

Potential Impact:
Considering that if just 1000 such Households use ThermaVault instead of Electric/Gas Based devices then that means that the yearly CO_2 Emissions will potentially Drop by 30-50 Tonnes! (based on IEA data: ~0.9 kg CO_2 per kWh)
That is similar to planting around 2000 Trees per year!!
(The Data is based on the EPA (Environmental Protection Agency) estimates of 21 KG CO_2 absorbed per tree per year)

Estimated Budget:

We aim to keep the total project cost under ₹10,000:

1. Peltier Modules (2–3 units) ₹700–900
2. Heat Sink + Cooling Fan(s) ₹400–600
3. Microcontroller (eg., Arduino Nano or ESP32) ₹700–1000
4. Temperature Sensors (eg., LM35/DS18B20) ₹300–500
5. Lithium-ion Battery Pack (Optional) ₹1,000–1,500
6. Solar Panel (10–20W) ₹1,000–1,500
7. Thermally Insulated Container/Box ₹800–1,000

8. Miscellaneous (Wiring, Connectors, Circuits, etc.) ₹500–1,000

Total estimated cost: ₹6,000–8,000

We want to keep the design Simple and Modular so that it stays affordable and accessible for everyone. For that, Some components (like the Solar panel or Battery) can be Removed or Substituted with Smaller or Lower-Cost versions to cut down on Expenses.
(For example: using fewer Peltier Modules, A Smaller (Insulated) Box, or a Lower capacity Battery and/or Solar Panel, etc)

Clarifications:

Our project uses 'Peltier Modules' to work which may perform less efficiently in Cooling/Heating larger areas/objects. This is because they are not as Powerful compared to Industrial-Grade systems and are best suited for Small, Insulated spaces